WE CLAIM:

1. A thermal switch for controlling the flow of heat between a heat source and a heat sink, the thermal switch comprising at least one nanostructure, wherein the thermal switch is configured to alternately form a path of high thermal conductance between the heat source and the heat sink via the at least one nanostructure, and a path of low thermal conductance between the heat source and the heat sink.

2. The thermal switch of claim 1, further comprising an actuator configured to alternately move between a first position to form the path of high thermal conductance and a second position to form the path of low thermal conductance.

3. The thermal switch of claim 2, wherein the actuator is deflectable to alternately deflect between the first position in which the actuator contacts the at least one nanostructure to form the path of high thermal conductance and the second position in which the actuator is spaced from the at least one nanostructure to form the path of low thermal conductance.

4. The thermal switch of claim 3, wherein the actuator comprises an electrostatic transducer that deflects to the first position upon application of a voltage to the transducer.

5. The thermal switch of claim 3, wherein the actuator comprises a piezoelectric transducer that deflects to the first position upon application of a voltage to the transducer.

6. The thermal switch of claim 1, wherein the at least one nanostructure comprises a bundle of carbon nanotubes.

7. The thermal switch of claim 6, wherein the at least one nanostructure further comprises a matrix material between the carbon nanotubes.

8. The thermal switch of claim 1, further comprising a fluid-tight cavity interposed between the heat sink and the heat source, the at least one nanostructure being disposed in the cavity, and the cavity containing an insulating gas to increase the thermal resistance of the switch whenever the switch is activated to establish the path of low thermal conductance.

9. The thermal switch of claim 1, further comprising a fluid-tight cavity interposed between the heat sink and the heat source, the at least one nanostructure being

disposed in the cavity, and the cavity being evacuated to increase the thermal resistance of the switch whenever the switch is activated to establish the path of low thermal conductance.

10. A thermal switch for controlling the flow of heat into or away from a body, comprising:

at least one nanostructure; and

an activation element that is selectively movable between a first position to activate the thermal switch and allow heat to flow into or away from the body through the nanostructure, and a second position to de-activate the thermal switch to reduce the flow of heat into or away from the body.

11. The thermal switch of claim 10, wherein the at least one nanostructure comprises a bundle of carbon nanotubes.

12. The thermal switch of claim 11, wherein the at least one nanostructure further comprises a matrix material between the carbon nanotubes.

13. A thermal-switch assembly, comprising:

a first major layer;

a second major layer; and

a plurality of thermal-switch elements cooperatively formed between the first and second major layers, each thermal-switch element defining a heat-transfer path and being selectively and independently operable relative to each other to alternately increase and decrease the transfer of heat between the first and second major layers via the respective heat-transfer path.

14. The thermal-switch assembly of claim 13, wherein the thermal-switch elements comprise an array of thermal-switch elements formed by the first and second major layers.

15. The thermal-switch assembly of claim 13, wherein each thermal-switch element comprises a drop of a thermally conductive liquid disposed between the first and second major layers.

16. The thermal-switch assembly of claim 15, wherein each thermal-switch element comprises a flexible membrane formed in the first major layer that is selectively deflectable between a deflected position in which the membrane contacts a respective drop and a non-deflected position in which the membrane is spaced from the respective drop.

17. The thermal-switch assembly of claim 16, wherein:

each thermal-switch element comprises at least one first electrode mounted on a respective flexible membrane and at least one second electrode mounted on the second major layer; and

whenever a voltage is applied to the first and second electrodes of one of the thermal-switch elements, the respective flexible membrane is caused to deflect and contact a respective drop.

18. The thermal-switch assembly of claim 13, wherein each thermal-switch element comprises at least one nanostructure disposed between the first and second major layers.

19. The thermal-switch assembly of claim 18, wherein each thermal-switch element comprises a flexible membrane formed in the first major layer that is selectively deflectable between a deflected position in which the membrane contacts a respective nanostructure and a non-deflected position in which the membrane is spaced from the respective nanostructure.

20. The thermal-switch assembly of claim 19, wherein each thermal-switch element comprises at least one first electrode mounted on a respective flexible membrane and at least one second electrode mounted on the second major layer; and

whenever a voltage is applied to the first and second electrodes of one of the thermal-switch elements, the respective flexible membrane is caused to deflect and contact a respective nanostructure.

21. An energy-converting apparatus, comprising:

a first micro-transducer operable to convert energy in one form to energy in another form;

a second micro-transducer operable to convert energy in one form to energy in another form; and

at least one nanostructure disposed between the first and second micro-transducers and adapted to alternately establish a path of high thermal conductance between the first and second micro-transducers to facilitate the flow of heat therebetween and a path of low thermal conductance between the first and second micro-transducers to inhibit the flow of heat therebetween.

22. The apparatus of claim 21, wherein:

the first and second micro-transducers comprise first and second micro-heat engines, respectively, and each micro-heat engine being operable to convert thermal energy into electrical energy; and

heat from the first micro-heat engine is transferred to the second micro-heat engine whenever the path of high thermal conductance is established by the at least one carbon nanostructure.

23. The apparatus of claim 22, further comprising a load operatively connected to the first and second micro-heat engines, wherein the load consumes electrical energy generated by the micro-heat engines.

24. The apparatus of claim 21, wherein:

the first and second micro-transducers comprise first and second micro-heat pumps, respectively; and

heat rejected by the first micro-heat pump is transferred to the second micro-heat pump whenever the path of high thermal conductance is established by the at least one nanostructure.

25. The apparatus of claim 21, wherein:

the at least one nanostructure is in constant thermal contact with the first micro-transducer;

the second micro-transducer comprises a flexible membrane that is alternately deflectable between a deflected position and a non-deflected position; and

whenever the flexible member is in the deflected position, the flexible member contacts the at least one nanostructure to establish the path of high thermal conductance, and wherein whenever the flexible member is in the non-deflected position, the flexible member is spaced from the at least one nanostructure to establish the path of low thermal conductance.

26. A method for transferring heat from a heat source to a heat sink, the method comprising alternately establishing a low-thermal-resistance path between the heat source and the heat sink to allow heat to be conducted between the heat source and the heat sink through a nanostructure, and a high-thermal-resistance path between the heat source and the heat sink to inhibit the conduction of heat between the heat source and the heat sink.

27. The method of claim 26, wherein:

establishing the low-thermal-resistance path comprises contacting the nanostructure with the heat source and the heat sink; and

establishing the high-thermal-resistance path comprises creating a gap between the nanostructure and at least one of the heat source and the heat sink.

28. The method of claim 26, wherein:

the heat source comprises a low-temperature heat source of a thermoelectric cooler and the heat sink comprises a high-temperature heat sink of a thermoelectric cooler; and

the method further comprises selectively thermally coupling the low-temperature heat source to the thermoelectric cooler via the nanostructure to allow the thermoelectric cooler to absorb heat from the low-temperature heat source and pass heat to the high-temperature heat sink.

29. The method of claim 26, wherein:

the heat source is a first micro-transducer and the heat sink is a second micro-transducer; and

the method comprises intermittingly thermally coupling the first micro-transducer to the second micro-transducer to allow heat to be transferred from the first micro-transducer to the second micro-transducer through the nanostructure.

30. A micro-transducer, comprising:

a fluid-tight cavity;

a working fluid contained in the cavity;

a deflectable membrane bounding at least a portion of the cavity; and

a wick structure disposed on an inner surface of the cavity and configured to hold at least a portion of the working fluid.

31. The micro-transducer of claim 30, wherein the wick structure comprises a plurality of radially spaced, concentric wicks.

32. The micro-transducer of claim 30, wherein the wick structure comprises a plurality of radially extending, angularly spaced wicks.

33. The micro-transducer of claim 30, wherein the wick structure is made of photoresist.

34. The micro-transducer of claim 30, wherein the deflectable membrane comprises a piezoelectric membrane that is operable as an actuator to compress the working

fluid whenever an electric field is applied to the piezoelectric membrane and operable as a generator to generate an electric charge whenever the working fluid expands.

35. The micro-transducer of claim 30, wherein the working fluid is a saturated mixture of vapor and liquid.

36. The micro-transducer of claim 30, further comprising:

a first thermal switch configured to intermittently thermally couple the micro-transducer to a heat source to allow heat to flow from the heat source into the micro-transducer; and

a second thermal switch configured to intermittently thermally couple the micro-transducer to a heat sink to allow heat to flow from the micro-transducer to the heat sink.

37. The micro-transducer of claim 36, wherein:

the first thermal switch comprises a first nanostructure oriented such that heat flows through the first nanostructure whenever the micro-transducer is thermally coupled to the heat source; and

the second thermal switch comprises a second nanostructure oriented such that heat flows through the second nanostructure whenever the micro-transducer is thermally coupled to the heat sink.

38. The micro-transducer of claim 36, wherein:

the first thermal switch comprises a first drop of a thermally conductive liquid positioned such that heat flows through the first drop whenever the micro-transducer is thermally coupled to the heat source; and

the second thermal switch comprises a second drop of a thermally conductive liquid positioned such that heat flows through the second drop whenever the micro-transducer is thermally coupled to the heat sink.

39. A thermal switch for controlling the flow of heat between a heat source and a heat sink, the thermal switch comprising at least one drop of a thermally conductive liquid, wherein the thermal switch is configured to alternately form a path of high thermal conductance between the heat source and the heat sink via the at least one drop, and a path of low thermal conductance between the heat source and the heat sink.

40. The thermal switch of claim 39, further comprising an actuator configured to alternately move between a first position to form the path of high thermal conductance and a second position to form the path of low thermal conductance.

41. The thermal switch of claim 40, wherein the actuator is deflectable to alternately deflect between the first position in which the actuator contacts the at least one drop to form the path of high thermal conductance and the second position in which the actuator is spaced from the at least one drop to form the path of low thermal conductance.

42. The thermal switch of claim 41, wherein the actuator comprises an electrostatic transducer that deflects to the first position upon application of a voltage to the transducer.

43. The thermal switch of claim 41, wherein the actuator comprises a piezoelectric transducer that deflects to the first position upon application of a voltage to the transducer.

44. The thermal switch of claim 39, wherein the drop is about 10 microns to about 1000 microns in diameter.

45. The thermal switch of claim 39, wherein the drop comprises mercury.

46. The thermal switch of claim 39, further comprising a fluid-tight cavity interposed between the heat sink and the heat source, and wherein the at least one drop is disposed in the cavity, the cavity containing an insulating gas to increase the thermal resistance of the switch whenever the switch is activated to establish the path of low thermal conductance.

47. The thermal switch of claim 39, further comprising a fluid-tight cavity interposed between the heat sink and the heat source, and wherein the at least one drop is disposed in the cavity, and a vacuum is established in the cavity to increase the thermal resistance of the switch whenever the switch is activated to establish the path of low thermal conductance.

48. A thermal switch for controlling the flow of heat into or away from a body, comprising:

a drop of a thermally conductive liquid; and

an activation element that is selectively movable between a first position to activate the thermal switch and allow heat to flow into or away from the body through the drop, and a second position to de-activate the thermal switch to reduce the flow of heat into or away from the body through the drop.

49. The thermal switch of claim 48, wherein the liquid is a metal.

50. The thermal switch of claim 48, wherein the drop is disposed on a metal contact.

51. A method for transferring heat from a heat source to a heat sink, the method comprising alternately establishing a low-thermal-resistance path between the heat source and the heat sink to allow conduction of heat between the heat source and the heat sink through a drop of a thermally conductive liquid, and a high-thermal-resistance path between the heat source and the heat sink to inhibit the conduction of heat between the heat source and the heat sink.

52. The method of claim 51, wherein:

establishing the low-thermal-resistance path comprises contacting the drop with the heat source and the heat sink; and

establishing the high-thermal-resistance path comprises creating a gap between the drop and at least one of the heat source and the heat sink.

53. The method of claim 51, wherein:

the heat source comprises a low-temperature heat source of a thermoelectric cooler and the heat sink comprises a high-temperature heat sink of the thermoelectric cooler; and

the method further comprises selectively thermally coupling the low-temperature heat source to the thermoelectric cooler via the drop to allow the thermoelectric cooler to absorb heat from the low-temperature heat source and pass heat to the high-temperature heat sink.

54. The method of claim 51, wherein:

the heat source is a first micro-transducer and the heat sink is a second micro-transducer; and

the method comprises intermittingly thermally coupling the first micro-transducer to the second micro-transducer to allow heat to be transferred from the first micro-transducer to the second micro-transducer through the drop.

55. A thermal cycler, comprising:

a tube-support device that supports one or more containers each configured to contain a sample to be processed by the thermal cycler;

a heat source configured to supply heat to the samples in the containers;

a cold source configured to supply cold to the samples in the containers; and

at least one thermal switch configured to selectively thermally couple the heat source or the cold source to the containers.

56. The thermal cycler of claim 55, wherein the thermal switch comprises at least one nanostructure configured such that heat flows through the nanostructure whenever the thermal switch thermally couples the containers to the heat source or the cold source.

57. The thermal cycler of claim 55, wherein the thermal switch comprises at least one drop of a thermally conductive liquid situated such that heat flows through the drop whenever the thermal switch thermally couples the containers to the heat source or the cold source.

58. The thermal cycler of claim 55, wherein the at least one thermal switch comprises a first thermal switch and a second thermal switch, the first thermal switch being configured to selectively thermally couple the heat source to the containers, and the second thermal switch being configured to selectively thermally couple the cold source to the containers.

59. A thermoelectric cooler, comprising:

a low-temperature heat source;

a high-temperature heat sink;

a thermoelectric element thermally coupled to the high-temperature heat sink; and

a thermal switch comprising at least nanostructure, the thermal switch being configured to couple the low-temperature heat source to the thermoelectric element and to allow heat to flow from the heat source to the thermoelectric element via the nanostructure.

60. A thermoelectric cooler, comprising:

a low-temperature heat source;

a high-temperature heat sink;

a thermoelectric ~~element thermally coupled~~ to the high-temperature heat sink; and

a thermal switch comprising at least one drop of a thermally conductive liquid, the thermal switch being configured to couple the low-temperature heat source to the thermoelectric element and allow heat to flow from the heat source to the thermoelectric element via the drop.

61. A thermal switch, comprising:

a body defining a fluid-tight cavity having first and second major surfaces;

a working fluid contained in the cavity, wherein the cavity is operable as a heat pipe to cause the working fluid to transfer latent heat from the first major surface to the second major surface;

a flexible membrane forming the first major surface of the cavity, the membrane being deflectable inwardly toward the second major surface of the cavity; and

at least one wick formed on the membrane and positioned to absorb working fluid that has condensed on the second major surface whenever the membrane is deflected inwardly toward the second major surface.